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(54) IMPROVEMENTS IN OR RELATING TO ELECTRIC VEHICLE SPEED CONTROL SYSTEMS

(71) We, LINDE AKTIENGESELLSCHAFT, a German Company of D-62 Wiesbaden Abraham-Lincoln-Strasse 21, German Federal Republic, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The invention relates to vehicle speed control systems for controlling vehicles which have an electric, in particular a d.c. motor drive, preferably a battery-electric drive, and which comprise an arbitrarily operable lever, preferably a pedal lever, by which is varied the magnitude of a current or voltage that preferably serves to control a pulse control unit which serves to control the drive motor current.

Previously the current magnitude has been varied by means of potentiometers, which were connected via an intermediate lever to the movement control pedal. A movement control pedal needs to be a component of sturdy design since it is subjected to impacts of considerable strength, in particular when the vehicle suffers vibrations. In comparison, electric potentiometers are delicate high-precision mechanical components. This means that, due to the direct coupling to the movement control pedal, the bearings of the mobile components of the potentiometer are subject to forces of a magnitude which lead to frequent damage. It is also known to use a telescopic set of coils, or a permanent magnet adjustably inserted into the air gap of a transductor, in place of a control potentiometer. However, these are also electrical components that are very sensitive, and suffer under the violent impacts to which they are subjected via the movement control pedal.

According to the present invention there is provided a speed control apparatus for the drive motor of an electrically propelled vehicle comprising a movable control member operable to adjust the position of a diaphragm in the light path between a light source and a photo-electric transducer, and motor current control means responsive to the output of the photo-electric transducer, in which the diaphragm is arranged to be movable from a central rest position in opposite directions for forward and reverse motion of the vehicle and the apparatus further comprises disabling means arranged, in operation, to prevent the supply of current by the current control means when the diaphragm is passing through its central position.

The photo-electric transducer is preferably a photo-resistor, and the disabling means may conveniently comprise a switching element connected in series with the photoresistor to interrupt current flow through said photo-resistor when the diaphragm is moved from a position corresponding to vehicle movement in one direction to a position corresponding to movement in the other direction.

The diaphragm can be an extremely sturdy and firmly mounted component, so that even very rapid sudden movements of the diaphragm in the light path have no adverse influence upon the sensitive electric components.

The invention will now be described with reference to the drawings, in which:–

Figure 1 schematically illustrates a side

view of one exemplary embodiment of the invention;

Figure 2 is a schematic front view of the embodiment shown in Figure 1;

Figure 3 shows a part of Figure 2 on a larger scale; and

Figure 4 is a circuit diagram of the embodiment shown.

In the embodiment shown in Figure 1, a hinged bearing 1 is provided for a vehicle speed control pedal 2 that is mounted on the vehicle frame (not shown).

A connecting lever 3 links the speed control pedal 2 to a pivot member 4 which is secured on a shaft 5. Also secured to the shaft 5 is a diaphragm 6 that has an opening 7, and a cam roller 8 which operates a movement-direction-reversal switch (not shown) via cam rails 9.

The electrical parts of the control system are arranged in a housing. A luminescence diode 13 and a photo-resistor 14 are arranged in bores in a cast block 10, which in this example consists of synthetic resin material and possesses a slot 12 into which the diaphragm 6 fits, the slot 12 being arranged between the luminescence diode 13 and the photo-resistor 14 in the block 10 in such manner that the light of the luminescence diode 13 only falls onto the photo-resistor 14 when the diaphragm 6 is not present in the slot 12 unless its opening 7 is aligned with the bores. The connection of these components can be seen in the circuit diagram illustrated in Figure 4. A battery supply voltage is applied between terminals 15 and 16. Via a resistor r2 the luminescence diode 13 is energised, and its light passes through the opening 7 of the diaphragm 6 onto the photo-resistor 14 when the diaphragm is in its mid-position. Adjustable resistors r4 and r5 are connected in a series chain together with a transistor T2 and control the base potential of a transistor T1 to form an impedance transformer which produces a uniformly controllable voltage which is dependent upon the current in the photo-resistor 14, and thus upon the position of the diaphragm 6, i.e. upon the movement control pedal setting, and an output voltage is obtained across terminals 17 and 18 and led to a controlled semiconductor switch supplying current to a motor driving the vehicle. A resistor r6 limits the maximum voltage that can appear at the base of the transistor T1. The photo-resistor 14 is designed as a large-area photo-resistor.

In the event of a transition of the diaphragm 6 from one operated state via the zero position into an operated state in the opposite direction it is necessary for the output voltage of the impedance transformer to fall rapidly to its lowest value when the pedal passes through its rest position, as otherwise, due to the slow response of the photo-resistor 14, if immediate operation is required in the opposite direction, an excessive current could arise, which would lead to a current surge in the vehicle drive motor. To prevent this, the transistor T2 is connected in series with the photo-resistor 14. This transistor T2 is controlled by contacts 19 and 20 of the movement direction switch that is operated by the cam 8 of Figure 1. Said contacts are open in the rest position of the pedal, so that in this state the voltage divider r3/r7 does not obtain any positive voltage via diodes n5 or n6, and the base of the transistor T2 is therefore held at zero volts with respect to its emitter via the resistor r7. The transistor T2 is thus blocked. The voltage divider chain comprising r4/r5/14/T2 is thus non-conductive and the base of the transistor T1 is maintained at a bias voltage which is formed by the voltage divider r4/r6. In this state the output of the impedance transformer assumes its lowest voltage value. In the event of operation of the pedal, when one of the movement direction switch contacts 19 or 20 provides a positive potential to the transistor T2 via the resistor r3, the transistor becomes conductive. If, at the time of a reversal of movement, the photo-resistor does not reach its greatest resistance value, nevertheless, due to the turning off of the transistor T2, the impedance transformer output inevitably moves down to the low value determined by r4 and r6. This output avoids the current surge which could arise at the instant of switch-over if the photoresistor 14 is still exhibiting a resistance value indicative of a diaphragm 6 that is only partially moved outwards, even though the diaphragm 6 is actually completely interrupting the light flow. Thus the disadvantages of the photo-resistor 14 are avoided by the additional connection of the transistor T2.

The diaphragm is adjustable towards either side from the central rest position, and is coupled to a movement-direction-reversing switch in such manner that when the diaphragm is pivoted out of the central position in one direction, the movement-reversing switch is switched to provide control in one movement direction, and when it is pivoted into the other direction, the movement reversing switch is switched to provide control in the other movement direction. The diaphragm can be designed in such manner that when it is moved in either direction out of the central rest position an identical degree of movement results in an identical change in cross-section of the light path, or alternatively movement in one direction may be arranged to have a different effect on the light path to that for the other direction, for example, so that when reverse motion is selected the same degree of pedal movement results in a lower speed

of the vehicle.

The diaphragm can be designed in such manner that for each unit of displacement the change produced in the light path is of a predetermined value, for example in such manner that in the region of the starting position a relatively large displacement of the diaphragm results in only a relatively small change in the light flow, whereas in the event of considerable movement of the diaphragm the same change in displacement results in a considerable change in the light flow, so that the speed of vehicle movement at low speeds can be controlled with greater sensitivity.

A luminescence diode light source is particularly expedient because the light strength of a luminescence diode is substantially constant, and also because the energy consumption is very low, and thus no difficulties arise with regard to heat discharge. In addition, luminescence diodes have a very long life span and are very insensitive to vibrations.

Even when the movement control pedal is subject to a very hard and sudden impact the electronic components cannot be adversely affected, since the latter components are not physically connected to the mechanical components, except via the vehicle frame.

In the central rest position the light beam can be fully exposed, as shown in the illustrated embodiment, or completely blocked from the element which serves to convert the light flow into an electric output current or voltage.

The transducer element which serves to convert the light flow into an electric current or voltage can be a normal photocell instead of the photo-resistor used in the illustrated embodiment. However, a large-area photo-resistor is advantageous because the large area will mean that any inaccuracies in the position of the diaphragm in relation to the photo-resistor are of insignificant effect and a sufficiently large path is available for the diaphragm. This facilitates a very sensitive, but also price-favourable and sturdy control.

A disadvantage of a photo-resistor is the slow response time, since when the light flow is completely interrupted a considerable period of time passes before the resistor has assumed the dark-value.

As described above, this can result in the fact that on transition from one movement direction into the other, when a new movement direction is first selected the pulse control unit is still supplied with a specific voltage since the photo-resistor had not yet reached its dark value and the output is not at the rest level, so that consequently a surge occurs in the electric motor drive on switch-over. To avoid this disadvantage the photo-resistor is connected in series with an element which interrupts the current flow through the photo-resistor on switch-over from one movement direction to the other, and thus causes the pulse control unit to reduce the motor current to zero. In the illustrated embodiment this further element is the transistor T2 whose base voltage is interrupted on switch-over, and it is thus achieved that even in the event of a rapid transition from one movement direction via the zero position into the opposite movement direction, the voltage at point 17 rises, i.e. the output voltage (between points 17 and 18) of the impedance transformer which is controlled by the photo-resistor rapidly falls to its lowest value when the pedal passes through the zero position.

The element which serves to convert the light flow into an electric current is connected at its output to an amplifier (T1) known *per se* which can itself be connected to the usual components of the electric motor speed control unit without modification.

The design permits the control to be used in many ways with or without small modifications, so that one and the same control system can be used for vehicles whose drives are designed for various voltages, e.g. between 24 and 80 V.

With suitable modifications, this control system can also be used for vehicles utilising contactor control rather than the controlled semiconductor switch mentioned above.

It is thus possible to combine a control system constructed in accordance with the invention with various motor speed control units and thus to use one and the same control system in vehicles of different types.

This system can be constructed as a printed circuit, and this can be mounted together with other control components of the motor speed control unit and possibly with yet other electric control components, in a closed housing so that all the control components are protected from environmental influences.

WHAT WE CLAIM IS:–

1. A speed control apparatus for the drive motor of an electrically propelled vehicle comprising a movable control member operable to adjust the position of a diaphragm in the light path between a light source and a photo-electric transducer, and motor current control means responsive to the output of the photo-electric transducer, in which the diaphragm is arranged to be movable from a central rest position in opposite directions for forward and reverse motion of the vehicle and the apparatus further comprises disabling means arranged, in operation, to prevent the supply of current by the current control means when the diaphragm is passing through its central position.

2. An apparatus as claimed in Claim 1,

in which said diaphragm is designed in such manner that initial movement thereof from said central position causes a relatively small change in the transducer output whilst further movement causes a relatively larger change.

3. An apparatus as claimed in any preceding Claim, in which said light source is a luminescence diode.

4. An apparatus as claimed in any preceding Claim, in which said transducer is a photo-resistor.

5. An apparatus as claimed in Claim 4, in which said disabling means comprises a switching element connected in series with the photo-resistor to interrupt current flow through said photo-resistor when the diaphragm is moved from a position corresponding to vehicle movement in one direction to a position corresponding to movement in the other direction.

6. An apparatus as claimed in Claim 5, in which said switching element is a transistor whose base is connected via respective blocking diodes to each of two contacts of a switch operable by movement of the control member which moves the diaphragm in either of said directions.

7. An apparatus as claimed in any preceding Claim, in which the current control means is of the type comprising a controlled semiconductor switch for supplying pulses of current to the drive motor of the vehicle.

8. A speed control apparatus for the drive motor of an electrically propelled vehicle substantially as herein described with reference to the accompanying drawings.

9. A battery-electric-operated fork-lift truck provided with a speed control apparatus as claimed in any preceding Claim.

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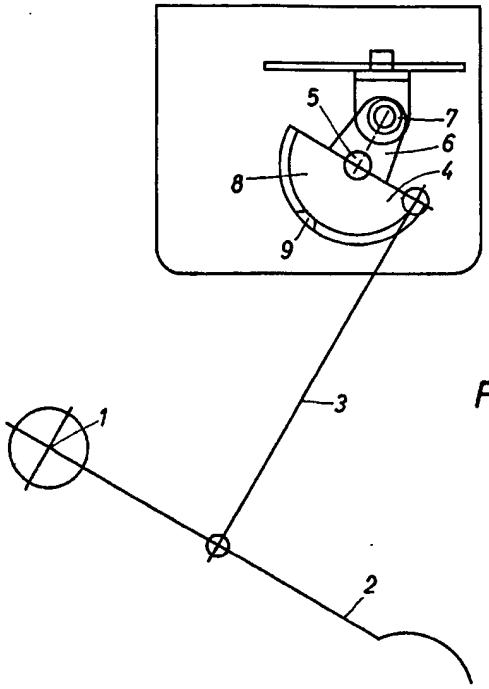

Fig. 1

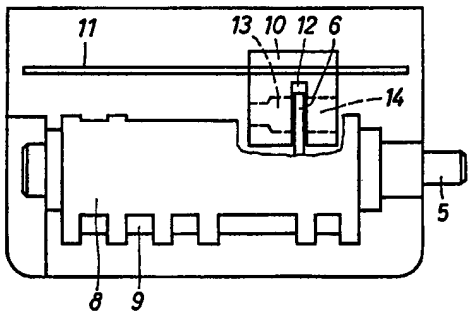

Fig. 2

1519853 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

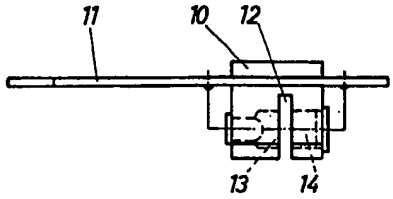

Fig. 3

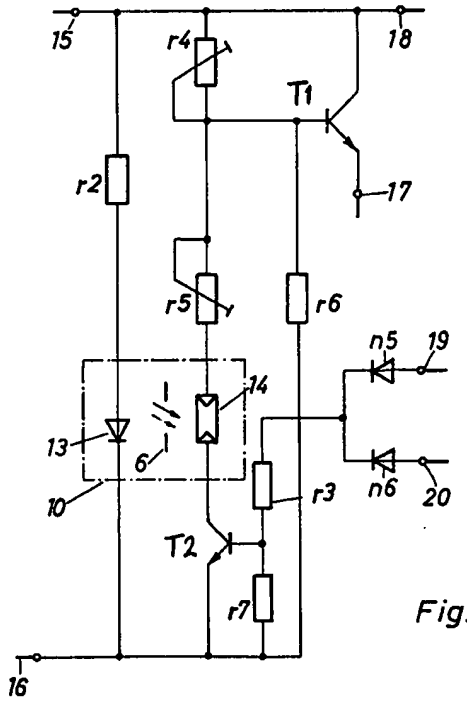

Fig. 4